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Numerical simulation of excitation-contraction coupling in a locus of the small bowel

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Abstract

A mathematical model for the excitation-contraction coupling within a functional unit (locus) of the small bowel is proposed. The model assumes that: the functional unit is an electromyogenic syncytium; its electrical activity is defined by kinetics of L- and T-type Ca2+-channels, mixed Ca2+-dependent K+-channels, potential-sensitive K+-channels and Cl--channels; the basic neural circuit, represented by the cholinergic and adrenergic neurones, provides a regulatory input to the functional unit via receptor-linked L-type Ca2+-channels; the smooth muscle syncytium of the locus is a null-dimensional contractile system. With the proposed model the dynamics of active force generation is determined entirely by the concentration of cytosolic calcium. The model describes electrical processes of the propagation of excitation along the neural circuit, chemical mechanisms of nerve-pulse transmission at the synaptic zones and the dynamics of active force generation. Numerical simulations have shown that it is capable of displaying different electrical patterns and mechanical responses of the locus. The simulated effects of: tetrodotoxin, β-bungarotoxin, salts of divalent cations, inhibitors of catechol--methyltransferase and neuronal uptake mechanisms, and changes in the concentration of external Ca2+ on the dynamics of force generation have been analysed. The results are in good qualitative and quantitative agreement with results of experiments conducted on the visceral smooth muscle of the small bowel.